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Host Plant Preference, Mating and Egg Development in *Synnoma lynosyrana*

(Lepidoptera: Tortricidae)

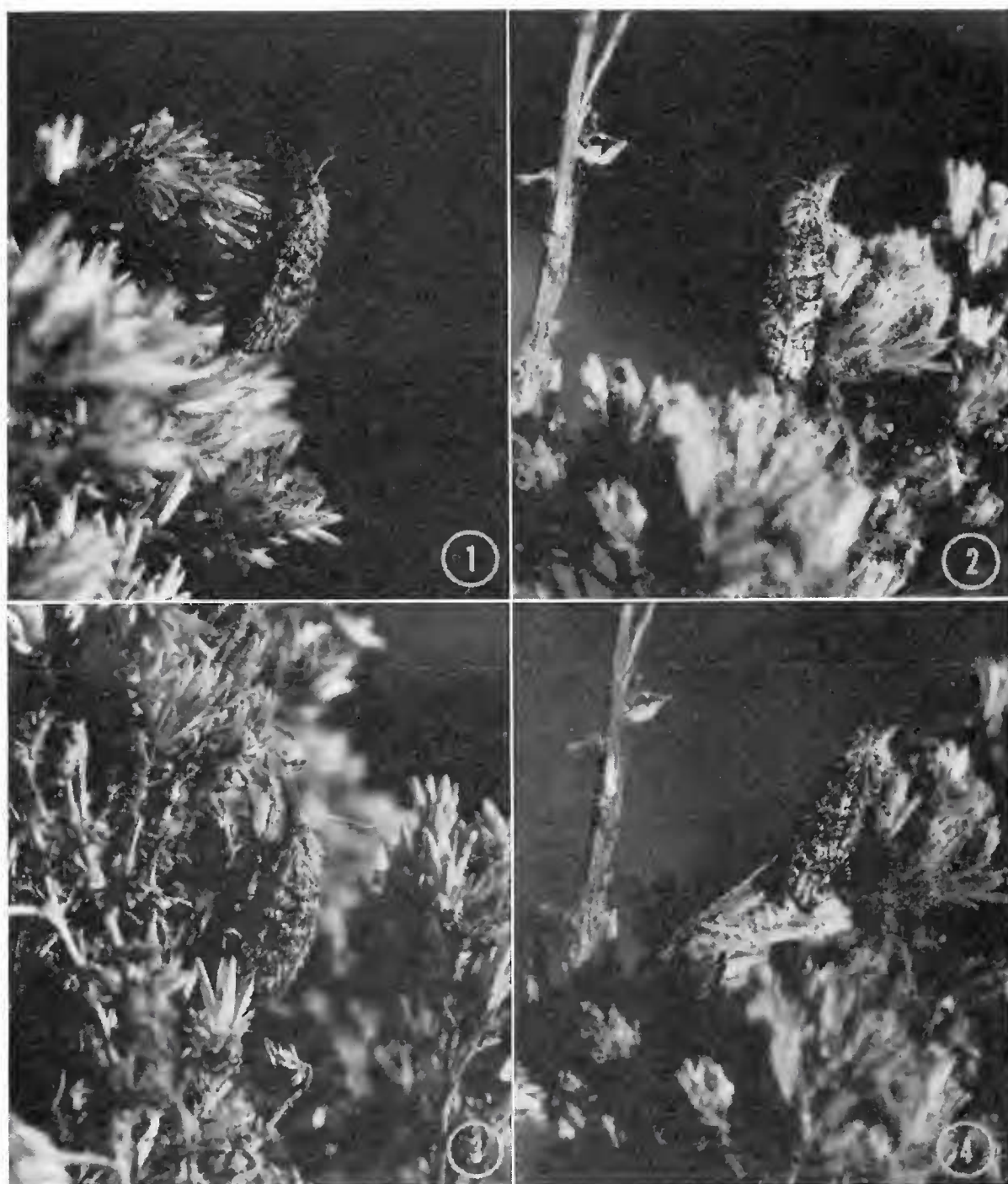
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In several ways *Synnoma lynosyrana* Walsingham is unique among American Tortricinae. Like many Sparganothidini, this species exhibits marked sexual dimorphism, but in contrast to all other members of the tribe, the female of *Synnoma* evidently is flightless. Males possess strongly pectinate antennae, whitish ochreous forewings flecked with shining bluish silver, and dark brown hindwings, while females have filiform antennae, an immensely enlarged abdomen, lack most of the ochreous scaling on the shining bluish black forewings, and have dull gray-brown hindwings. Elongate vestiture on the body and appendages and strongly upraised scaling on the forewings, gives both sexes a ruffled, shaggy appearance (figs. 1-3).

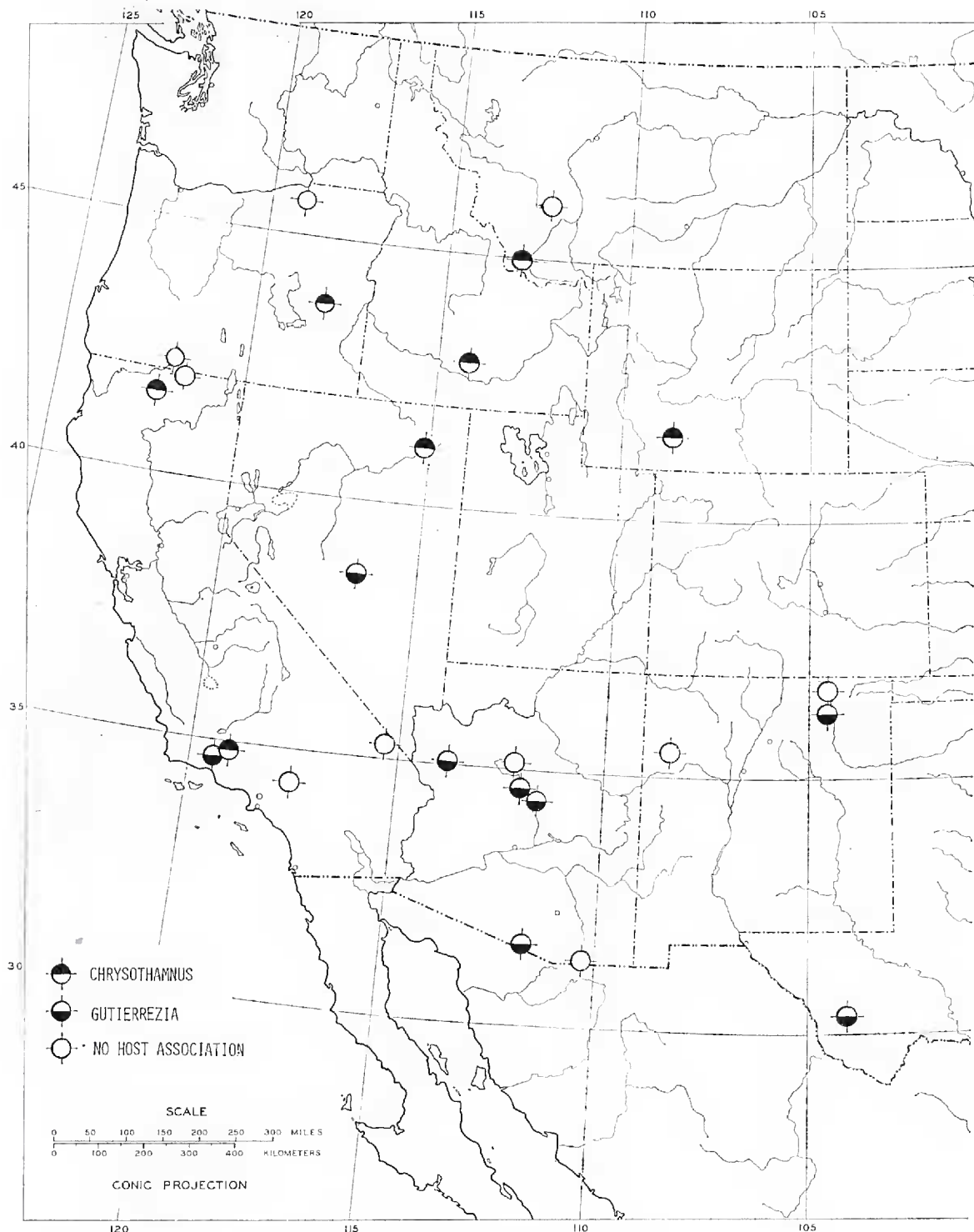
Synnoma lynosyrana was discovered by Lord Walsingham near Mt. Shasta in northern California in 1871, when he reared adults from larvae on *Lynosyris* (Compositae) (Walsingham, 1879), a shrub now known as *Chrysothamnus*. Other than a brief report nearly a century later (Powell, 1959) and a description of the larva by MacKay (1962), nothing has been recorded on the biology or distribution of this interesting insect. We now know the species to be widespread in Great Basin and Mojave Desert regions, from southern Montana, Idaho and Wyoming through eastern Oregon, northeastern California, Nevada and Arizona to extreme western Texas, with an apparently isolated population at the western edge of the Mojave in southern California (map 1). Records are lacking from eastern Washington, Colorado, and Utah, although the species no doubt ranges into some of these areas.

A generalized life history is as follows. There is a single annual generation, adults emerging in the fall, from October in the north to November in the south. The moths rarely have been observed in the field, in part owing to their late seasonal occurrence and in part to



FIGS. 1-4, *Synnoma lynosyrana* Walsingham (JAP 73H8-9): 1, 2, female in characteristic "calling" posture; 3, female perched in foliage, a cryptic position taken at night or after external disturbance; 4, mating pair.

their diurnal behavior, which precludes light attraction records. The eggs are deposited in elongate clusters on the twigs of certain woody Compositae and enter diapause or a prolonged temperature related quiescence, probably until early spring. Young larvae evidently migrate down the stems and feed on newly developing foliage. Later instar larvae live in aggregated clusters of tough silken tubes, tying up the branches into conspicuous bundles. They emerge from these shelters



MAP. 1. Distribution of locality records for *Synnoma lynosyrana* Walsingham in the western United States. Top half closed circles indicate larval collections from *Chrysothamnus*, bottom half closed circles indicate records from *Gutierrezia*. Open circles indicate collections of adults without host plant information.

to forage on leaves and green bark. Pupation occurs in the larval galleries in the fall.

Host plant selection.—Although *Synnoma lynosyrana* has been reared from various composites of the genera *Chrysothamnus*, *Gutierrezia*, and *Haplopappus*, these plants are not used randomly over the whole distri-

bution of the moth. A general pattern emerging from field work and museum specimen records indicates that the species is dependent on *Chrysothamnus* over the northern half of its range, and in the Great Basin, and primarily on *Gutierrezia* in southern parts of its distribution (map 1). In northern California and northeastern Nevada I found larvae on both *Chrysothamnus nauseosus* and *C. viscidiflorus* (58H2-4, 73H8-9),¹ while records from southern Idaho, Montana (MacKay, 1962) and Wyoming (67J6) involve only the latter plant. Southward, the larval shelters have been collected on *Gutierrezia* at the northern edge of the Mojave in south central Nevada (68G33), at five localities in Arizona and northern New Mexico (68F19, 68F40, museum specimens), and in the Big Bend region of Texas (MacKay, 1962). Most collections from *Gutierrezia* have been made too early in the season to enable specific identification of the host plant. A specimen label from Springer, N.M., gives *G. sarothrae*, a widespread species, as a host. Probably various species of the genus are used.

This pattern is supported by negative evidence accumulated during an extensive survey of these plant genera conducted during 1966–1968. *Chrysothamnus* and *Haplopappus* were examined during late July to October at numerous stations in Nevada, eastern and southern California, and Arizona without disclosing evidence of *Synnoma*. Thus, although the distributions of the latter two plant genera are broadly sympatric with that of *S. lynosyrana* over wide areas, these hosts are not utilized in the southern, more xeric regions. Exceptions that may represent incidental or temporary associations occur at the western edge of the Mojave in southern California. Near Frazier Park a sparse colony of *Synnoma* was discovered on *Chrysothamnus nauseosus* in 1961 (61H2). However, we were unable to relocate larvae at this site in 1967 and 1973. Approximately 40 km to the east in the Cuyama Valley we found an extensive population on *Gutierrezia* in October, 1967 (67K94). Here *C. nauseosus* growing abundantly in the riverbed was not used by the moth, but two plants of *nauseosus* among the *Gutierrezia* on slightly higher ground harbored many *Synnoma* larvae (67K95). *Haplopappus linearifolius* was also utilized in an isolated instance in the Cuyama Valley. We found no larvae on this plant in 1967, but in October, 1972, with shelters again common on *Gutierrezia*, an extensive survey of all three host plants disclosed one bush of *H. linearifolius* with several larvae (72K1). This species is distributed primarily in the Coast Ranges in somewhat more mesic habitats than *Synnoma*, and at Cuyama Valley loses most of its foliage by the end of the dry season. Because of its

¹ Data for collections accompanying these rearing numbers is given in the appendix.

deciduous habit it seems doubtful that *H. linearifolius* could support an extensive colony of larvae, and here *Chrysothamnus* and *Haplopappus* appear to be incidental hosts used by a population of *Synnoma* which is essentially dependent on *Gutierrezia*. Other species of *Haplopappus*, particularly *H. venetus*, *H. acradenius* and *H. tenuisectus* (= *hartwegii*), were examined many times within the range of *S. lynosyrana* with negative results.

Diel rhythm and longevity of adults.—Observed emergences from the pupa were between 0715 and 0906 PST (67J6, $n = 10$), and at least some took place earlier in the morning. Wing expansion and drying in four timed examples required 16–20.5 minutes (8–9.5 minutes from breaking of the pupal shell until the wings were fully lengthened, then 7–11 minutes with the wings held erect from the body before being folded into the normal position over the dorsum).

In contrast to nearly all other Nearctic Tortricinae, moths of the present species are diurnal. We observed males flying on a clear day in early November at 1030–1130 PST, near Gorman, California (74L2), despite a stiff, cool breeze. During intermittent calm periods and in sheltered spots the moths actively fluttered above *Chrysothamnus* foliage, apparently independent of observer disturbance. Repeated surveillance of confined individuals made during darkness hours in presence or absence of artificial lighting revealed virtually no movement of *Synnoma* adults (67J6, 67K94). Occasionally females continued oviposition in darkness after initiating egg-laying late in the day. Activity in the laboratory was greatest between 1230 and dusk, ceasing about 30 minutes after sundown (ca. 1830 in September, to 1730 in October) (67K94, 73H8-9). Occasional movement by both sexes occurred between 0730–1200, but most individuals remained inactive during the morning. Some females assumed the “calling” position perched atop an inflorescence (figs. 1, 2) early in the morning and if not mated sometimes remained so perched until well after dark. On cloudy days moths housed in a trailer lab (18°C) remained inactive.

During warmer hours of the day males displayed a positive phototactic reaction, flying from open containers to windows, fluttering at sides of containers towards sunlight, etc. Although females sometimes dropped from open bouquets of the plants, they were not attracted to sunlit windows. Any movement or jostling of the plant usually caused females at calling perches to quickly back down the stem into foliage, but none was ever observed to attempt flight. Following mating and oviposition, several females died at the bottom of containers, even though there was no closure confining them. Under field conditions, it

is possible that females fly after a portion of the egg complement has been deposited, but my observations do not suggest this.

Adults were comparatively short-lived, surviving only 5–9 days in standardized one-gallon breeding jars (Powell, 1964). None was observed to visit the water source that was provided, and dissections revealed the tongue to be extremely reduced and apparently non-functional in both sexes, with the galea lobes separated and only about 0.3 mm in length. Thus it appears that *Synnoma lynosyrana* is adapted for survival without nourishment as are late fall and winter-flying ethmiid moths of arid regions in the western Nearctic (Powell, 1971, 1973). Female *Synnoma* housed without cage enclosures and without a water source produced fertile egg masses of apparently normal size, but individual longevity records were not maintained (73H8-9).

Courtship and mating.—Although viable eggs were obtained from caged adults, sexual behavior of the moths was successfully observed only in 1–3 day old individuals placed outside under conditions of natural air movement (73H8-9).

Pairs were tested at Berkeley in September, between 1500–1730 in a light westerly wind. Under field conditions mating behavior is probably related to temperature and may also occur earlier in the day. As soon as containers with dry *Chrysothamnus* inflorescences and moths were placed outside in a light breeze, males commenced a characteristic search behavior in which they quickly crawled over the foliage, rapidly fluttering their wings. This activity is unlike any other tortricid movements I have seen. Males which took flight sometimes remained aloft for several minutes, generally hovering up and down 1–3 m above the ground (females were stationed at a height of 1.5 m). If a male flew upwind from the female station no reaction was obvious until he drifted downwind to the east of the female. Downwind, males were observed to detect the pheromone plume, from as far away as 10 m, as evidenced by a sudden change in flight pattern from hovering in vertical arcs to a flight directly towards the female perch, wavering only 10–20 cm from side to side. Arriving at the *Chrysothamnus*, males immediately initiated the fluttering behavior and rapidly crawled from one inflorescence to another if the branch was not occupied by the female. This search behavior sometimes required up to 60 seconds including three or four pauses of a few seconds duration each.

Once a female was encountered, the courtship sequence was brief. The male quickly crawled around the female, oriented head to head, with his abdomen curled towards her and his valvae widely spread. When genital contact occurred, coupling was immediate, and the



FIGS. 5, 6, *Synnoma lynosyrana* (Walsingham) (JAP 73H8-9): 5, mating pair; 6, female perched above egg cluster.

male turned to assume the tail-to-tail position that is characteristic of all tortricids *in copulo* (figs. 4-5). No reaction by the female was evident during courtship. Her wings were held in repose, with the large abdomen protruding beyond. The whole courtship sequence required 2-10 seconds in several timed examples. Sometimes copulation occurred almost immediately, but in about half the encounters the male approached head first to the tip of the female's abdomen at the onset of contact before orienting in a head-to-head position alongside the female.

Several attempts were made to elicit courtship response on exposed *Chrysothamnus* bouquets in a trailer lab (73H9). Three successive first-day males were released near a newly emerged female perched in calling position at 1645-1700 with indirect lighting from late afternoon sun. Each began the courtship fluttering behavior immediately, moving up and down in the foliage but mostly well below the female. Brief periods of pause were interspersed with activity, but the female was not closely approached. Each male stopped altogether after 1.5-2 minutes and did not move again for 10 minutes. Lightly blowing across the female towards the inactive male resulted in some further brief activity but no closer approach to the female. Apparently, natural air movement, and

possibly direct sunlight, is necessary for effective tracking of the scent plume.

Females remained in position, head-upward on the plant terminal during courtship and mating, sometimes with the male arranged awkwardly sideways due to interposing foliage. The duration of copulation was short compared to other Tortricinae (Powell, 1964:27), lasting 12–19 minutes (avg. 17 min., $n = 4$) in examples where I witnessed both courtship and separation.

Following unsuccessful mating attempts, consisting of coupling for a few seconds to a few minutes, females were immediately attractive to the same or another male. On one occasion, a male was attracted in flight from a distance of about 1 m to a mating pair that had coupled 2–3 minutes previously. At termination of successful mating, the male flew off while the female either remained stationary or moved a few cm away from the calling location. In one instance the male was observed to fly around 2–3 minutes, finally coming to rest about 5 m distant and was not attracted by other females placed at the calling station during the succeeding 40 minutes. Whether mated females continue broadcasting the pheromone and are capable of mating again during the same diel cycle was not ascertained. Dissections of females that had successfully mated and deposited eggs revealed a single spermatophore in each (67K94, $n = 6$). Thus, under laboratory conditions females evidently mate only once, but individually labelled females were not tested under outdoor conditions on successive days. The spermatophores are amorphous and irregular in size compared to those of other Tortricidae, so that confirmation of their number is difficult (and is further complicated by the sticky, black accessory fluid which fills the corpus bursae). Thus further studies are needed to confirm that females mate but once.

Oviposition.—The eggs are normally deposited in elongate patches on the twigs of the host plant, usually about 4–5 cm below the flower heads (figs. 6–8). Occasional masses are placed near the apex of broken stems or on lower stems. Each egg mass consists of a double row of regularly arranged, imbricate eggs. The size of these clusters varies considerably and in the laboratory may be affected by such factors as density of moths, observer disturbance, etc. One female in a breeding jar also housing two males, laid individual patches containing 8–46 eggs (67J6, avg. 29, $n = 6$), while those deposited by several females on exposed bouquets of *Chrysothamnus* were larger, ranging 70–116 (73H8-9, avg. 92, $n = 6$). Sometimes irregular masses were deposited



FIG. 7, egg cluster of *Synnoma lynosyrana* Walsingham deposited in the lab on dry *Chrysothamnus* foliage (JAP 67K93.1); fig. 8, closeup of a portion of the same cluster.

on paper toweling at the bottom of the containers, possibly by older, weakened females.

Oviposition was observed only twice (67J6, 73H8), at 1730 and 1930 (before sundown and well after dark) in September. Several other occurrences of egg deposition were recorded between these hours, and a few later at night (at 18–20°C). In one instance a female under surveillance placed approximately 26 eggs during 10 minutes in a lighted room (67J6). Each egg-laying was brief but was followed by a long period (15–40 seconds) in which the female reconnoitered the position of the next egg by tapping the surface of the prior two or three eggs and adjacent stem with the papillae anales.

The precise number and time interval between eggs were difficult to observe because of a black substance secreted around the eggs that acts as an adhesive and perhaps as a protective agent. The source of this material is a pair of huge accessory glands lying alongside the ductus

bursae and filling the tip of the abdomen in virgin females. The liquid is secreted with each egg, rather than over the whole patch at its completion, as was evidenced when a female was interrupted after depositing only a short row which included the normal amount of accessory fluid. Other Sparganothidini cover the eggs with milky or clear, cement-like secretions (Powell, 1964:31), and no other American tortricine moths are known to produce a black substance for the eggs.

The total number of eggs deposited by a female ranges from 230–280. For example, a single female isolated in a breeding jar deposited 233 eggs after the fourth day following emergence (67J6). Owing to the short lifespan of the adults and the fact that the mouthparts are rudimentary, it might be expected that the eggs are deposited within a few days with little successive egg maturation involved. Dissection of virgin females indicated this to be the case. Examination showed 180 full sized or nearly full sized eggs and about 80 eggs of varying decreasing sizes in a female on the day of emergence (67K94), while an unmated female that lived several days contained about 275 full sized eggs and only a few smaller ones (73H9). In females that were retained alive for one or more days following mating, dissections showed no indication of continued egg production, with 20–220 full sized eggs remaining following oviposition (67K94).

Egg development.—When eggs were housed in the laboratory, ($20^{\circ} \pm 2^{\circ}\text{C}$), larvae began to emerge in 36–40 days (58H3-4, 67J6, 73H8-9). This is a considerably longer period than is normal in Tortricinae, yet shorter than in the usual obligate diapause (Powell, 1964:34). The emergence pattern is similar to that of eggs of the winter-active *Ethmia charybdis* Powell (Powell, 1971). Experiments with *Synnoma* indicated that incubation can be delayed by reduced temperatures. Some of the 73H8-9 eggs were transferred to an outdoor cage at Berkeley after 30 days in the laboratory, and emergence was delayed to 43–47 days. Other egg masses of this lot were moved to an outdoor shed at Russell Reserve, an inland station at about 250 m elevation, after 18 days in the laboratory. No larval eclosion occurred there, with weekly averages of daily mean temperatures, in successive weeks: 13, 9.5, 9, 9, 8, 3, 4, 4, 3.5, 4, 6, 0.5, 0.5, 7.5. After 70 days one egg cluster was transferred to the lab in Berkeley, where larvae emerged 20–24 days later. The final clusters were removed from the shed on January 20, 1974 after 100 days, and larval hatching occurred 16–17 days later. Under these conditions, the percent successful eclosion declined with longer cold storage. Thus it seems likely that under field conditions, egg maturation is delayed by the onset of cold temperatures after oviposition in late October to early

December, so that larval hatch does not occur through winter but commences with warming conditions in early spring, correlated with vernal foliation of the foodplants.

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APPENDIX

Biological Study Collections.—JAP 58H2: 1.5 mi NE Weed, Siskiyou Co., Calif. VIII-7-58 larvae on *Chrysothamnus viscidiflorus typicus*. JAP 58H3-H4: 10 mi NE Weed, Siskiyou Co., Calif. VIII-23-58 larvae on *C. viscidiflorus* and *C. nauseosus albicaulis*. JAP 61H2: 2 mi W Frazier Park, Kern Co., Calif. VIII-

24-61, larvae on *C. nauseosus mojavensis*. JAP **67J6**: Point of Rocks, Sweetwater Co., Wyo. IX-4-67, larvae on *C. viscidiflorus viscidiflorus*. JAP **67K94-K95**: Cuyama Vy., 3 mi S Ozena Jct., Ventura Co., Calif. X-6-67, larvae on *Gutierrezia californica* and *Chrysothamnus nauseosus mojavensis*. JAP **68F19**: 3 mi SE Kingman, Mohave Co., Ariz. VI-3-68, abandoned shelters on *Gutierrezia*. JAP **68F40**: 4 mi S Pine, Gila Co., Ariz. VI-5-68, abandoned shelters and young larvae on *Gutierrezia*. JAP **68G33**: 10 mi SW Clark's Sta., Nye Co., Nev. VII-20-68, Larvae on *Gutierrezia*. JAP **68G67**: 3 mi E Litchfield, Lassen Co., Calif. VII-24-68, larvae on *Chrysothamnus nauseosus consimilis*. JAP **72K1**: Cuyma Vy., 6 mi N Ozena Jct., Ventura Co., Calif. X-5-72, larvae on *Haplopappus linearifolius*. JAP **73H8-H9**: 2 mi W Wells, Elko Co., Nev. VIII-14-73, larvae on *Chrysothamnus nauseosus* and *C. viscidiflorus*. JAP **74L2**: 8 mi ESE Gorman, Los Angeles Co., Calif. XI-5-74, adults flying in assoc. *Chrysothamnus nauseosus mojavensis*.

RECENT LITERATURE

FRAGILE ECOSYSTEMS: EVALUATION OF RESEARCH AND APPLICATIONS IN THE NEOTROPICS. E. G. Farnworth and F. B. Golley (Eds.). The Institute of Ecology. Springer-Verlag, Berlin, etc. 1974. xxvii + 256 pp. \$7.80, paper.

TROPICAL ECOLOGICAL SYSTEMS (ECOLOGICAL STUDIES, VOLUME II). F. B. Golley and E. Medina (Eds.). The Institute of Ecology. Springer-Verlag, Berlin, etc. xvi + 398 pp. 1974. \$24.80, paper.

COMPLEX ADAPTATIONS IN EVOLVING POPULATIONS. T. H. Frazzetta. Sinauer Associates, Sunderland, Massachusetts 01375. 288 pp., 51 illustrations. 1975. \$4.95, paper; \$11.00, cloth.

ANIMAL BEHAVIOR: AN EVOLUTIONARY APPROACH. J. Alcock. Sinauer Associates, Sunderland, Massachusetts 01375. 1975. 526 pp., 259 illustrations. \$14.00, cloth.

COEVOLUTION OF ANIMALS AND PLANTS. L. E. Gilbert and P. H. Raven (Eds.). University of Texas Press, Austin 78712. 1975. xiv + 246 pp. \$12.50.

HISTORY OF ENTOMOLOGY IN THE PENNSYLVANIA DEPARTMENT OF AGRICULTURE. A. G. Wheeler and K. Valley. Pennsylvania Department of Agriculture, Bureau of Plant Industry, Harrisburg, Pennsylvania 17120. iii + 37 pp., available on request.

This useful descriptive work summarizes the history, present operations and biological holdings of the Pennsylvania Department of Agriculture. The present collection contains approximately 92,000 pinned insects and over 5000 slides and vials of immatures or soft-bodied adults. Especially well represented are Coleoptera, with 42,400 identified specimens.—Editor.